Ultrahigh Yield Strength Rhenium for High-Performance Combustion Chambers, Phase I

Completed Technology Project (2011 - 2011)

Project Introduction

The state-of-the-art material system for high-performance radiation-cooled liquid rocket engines is iridium/rhenium manufactured by chemical vapor deposition (CVD). As it has been produced for the past several years, Ultramet's CVD rhenium has a yield strength of 43 ksi and an elongation of 19%, which makes it very attractive for propulsion applications. For high-pressure applications, however, even higher yield strength, especially at elevated temperature, is desirable. To address this need, Ultramet will build upon its recent success in alloy deposition techniques. By adding easy-to-deposit alloying agents to niobium and tantalum, room temperature yield strengths were increased from 19 ksi to 69 ksi for niobium, and from 37 ksi to 98 ksi for tantalum, while still maintaining excellent ductility. At elevated temperatures, the latter alloy's yield strengths were 26 ksi at 1600

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C and 15 ksi at 1800

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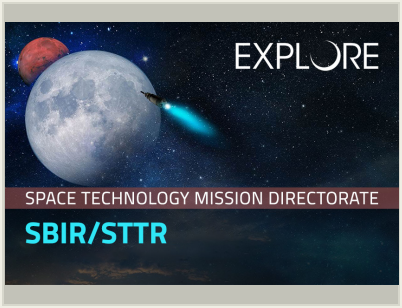
C, which compare quite favorably to rhenium's 19 and 11 ksi at the same temperatures. In this project, a similar alloying approach will be taken with rhenium to increase its yield strength, at both ambient and elevated temperatures. Increases in the rhenium yield strength will decrease the required wall thickness and hence reduce both the weight and cost of the combustion chamber. In addition to developing and characterizing novel rhenium-based alloys, the resulting properties will be used to modify the design of the 100-lbf Ir/Re flight chambers currently manufactured by Ultramet. The cost and weight savings afforded by using the new alloy in these bipropellant engines will be calculated. Designs will also be generated for a high-pressure 100-lbf chamber for NTO/MMH and a high-pressure 5-lbf chamber for use with the advanced, non-toxic monopropellant AF-315e. This latter chamber will be fabricated using the oxide-lined iridium/rhenium architecture, but the rhenium will be replaced with the higher-yield-strength alloy selected earlier.



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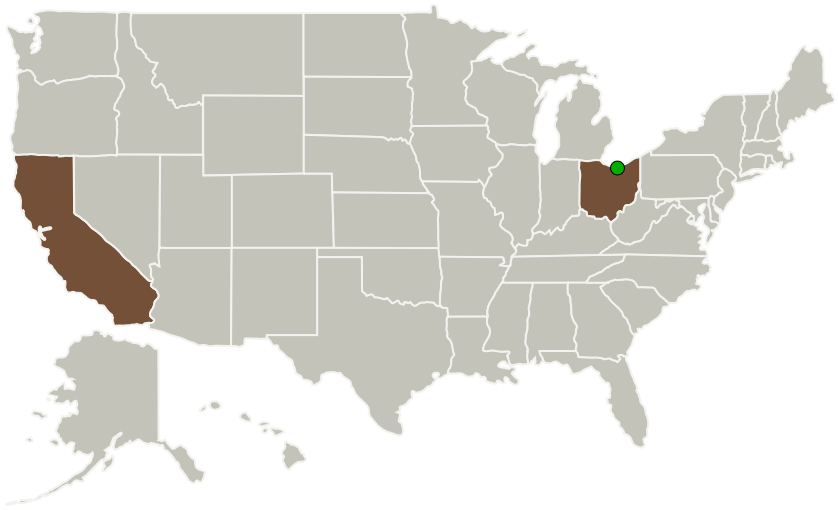
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Ultramet	Lead Organization	Industry	Pacoima, California
Glenn Research Center(GRC)	Supporting Organization	NASA Center	Cleveland, Ohio

Primary U.S. Work Locations	
California	Ohio

Project Transitions

February 2011: Project Start

September 2011: Closed out

Closeout Summary: Ultrahigh Yield Strength Rhenium for High-Performance C ombustion Chambers, Phase I Project Image

Closeout Documentation:

- Final Summary Chart Image*(https://techport.nasa.gov/file/137366)*

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Ultramet

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

Principal Investigator:

Arthur J Fortini

Co-Investigator:

Arthur Fortini

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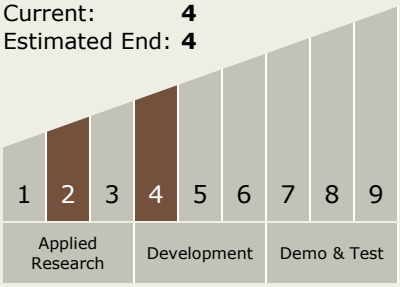
Completed Technology Project (2011 - 2011)

Technology Maturity (TRL)

Start: **2**
Current: **4**
Estimated End: **4**



Technology Areas

Primary:

- TX01 Propulsion Systems
  - TX01.1 Chemical Space Propulsion
    - TX01.1.3 Cryogenic

Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System